OXIDIZED FLAVORS IN DAIRY PRODUCTS

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INTRODUCTION

The purpose of this study was to devise methods for preventing the development of oxidized flavors in dairy products, with special emphasis placed on inhibiting this flavor in milk, butter and ice cream.

It is an established fact that flavor is one of the most important factors influencing the quality of all foods. Flavor is the voice of foods, the yardstick by which the individual determines whether a food product fulfils or falls short of the ideal. In no food industry does flavor play a more important part than in dairying. Yet, as one becomes familiar with the obstacles surrounding the interpretation of flavor, he finds there is a great difference in the evaluation of flavor by each individual. Since flavor plays such an important part in the dairy industry, the need for immediate and consistent scientific investigation of the most prevalent off-flavors is obvious.

On the official score card for judging dairy products, 25 points are allotted to flavor in milk, 45 points are given to flavor for butter and for cheese, while for ice cream 50 points are assigned to flavor. This evaluation shows the significance of flavor as established by the technically trained dairyman.

In scoring dairy products four of the five senses are employed. Listing them in order of their importance they are: smell, taste, sight and touch. Sight and touch are of little significance in determining and evaluating off-flavors. Therefore we shall limit our discussion to the senses of taste and smell.

The sense of taste is registered on the taste buds of the tongue and soft palate. According to Nelson and Trout (22) taste is limited to four different things, namely: sweet, sour, salt and bitter. The various parts of the tongue are sensitive to different tastes. Sweet and salt are most easily detected on the tip of the tongue while bitter belongs to the back part of the tongue and sour is usually associated with the sides of the tongue. Before the taste buds can register a taste, the stimulating substance must be capable of going into solution in water. If this stimulating substance is not in a liquid form when it enters the mouth, it must be dissolved in the saliva.

Many of the so-called flavors tasted in foods are actually recorded by the sense of smell. When a food is eaten and its flavor is recorded the sense of smell is actually employed. The aroma detected in the mouth goes back inside the head and then comes forward through the nasal cavity. The volatile constituents of the foods are recorded by the olfactory nerve, which is located in the upper part of the nose. Before the olfactory nerve can record a smell the substance must be volatile; that is, it must volatilize or continuously eliminate invisible particles which will readily mix with air. Most volatile chemical substances are more active at higher temperatures; which means any dairy product must enter the mouth while warm or it must be warmed in the mouth before the delicate volatile flavors can be detected. Flavors of dairy products are more readily detected when warmed to body temperature or higher.

The most simple classification considers only four different kinds of odors as follows:

1. Fragrant - flowers, fruit, perfumes.
2. Acid - sour milk, volatile acids, turpentine.
3. Burnt - formaldehyde, tar, strong coffee.
4. Caprylic - (goaty) rancid, cowy, rare cheese.

The aroma volatilized by any substance will depend upon the intensity of each of these four odors or their combinations. A larger amount of any food product is required for tasting in comparison to the amount necessary for smelling. A very minute amount, 1/10,000 of an ounce may be required for tasting while 1/1,000,000,000 of this amount if volatile may be sufficient for smelling.

Since flavor is a combination of taste and smell, any flavor deviating from the ideal in dairy products may be classed as an off-flavor. Different flavors are expected in the various dairy products. Nelson and Trout (22) say:

> "Normal whole milk is pleasantly sweet, possessing neither a foretaste nor an aftertaste other than that imparted by the natural richness of the milk."

A developed flavor is expected in butter. This flavor is produced by the action of citrovorus and paracitrovorus organisms on the citrates of milk. The citrates are converted into volatile acids which give butter its characteristic flavor and aroma. Cheese also has a developed flavor which is produced by the action of microorganisms. Ice cream, unlike the other three products mentioned, depends chiefly for its flavor upon the blending of different dairy products used in making the mix and upon fruits, flavors and other materials which are added.

Abnormal Milk Flavors

Gamble and Kelly (11) classify abnormal flavors into four main groups, as follows:

> "1. The internal or physical condition of the individual cow.
> "2. Those absorbed within the body of the cow from highly flavored feeds.
> "3. Odors absorbed in the milk after production.
> "4. Bacterial development within the milk on standing."

Chilson (4) in working on oxidized flavors in milk added another abnormal flavor to the group presented by Gamble and Kelly (11). Chilson

(4) believes there is a fifth group of off-flavors which may be contributed to chemical action within the milk on standing.

These off-flavors will be grouped and discussed differently.

I. Flavors present when the milk is drawn.

(a). Odors absorbed within the body of the cow from highly flavored feeds or any highly flavored material given the cow.

(b). The internal or physical condition of the individual cow.

II. Flavors developed after the milk is drawn.

(a). Odors absorbed in the milk after production.

(b). Flavors caused by bacterial development within the milk on standing.

(c). Flavors caused by the contamination of milk with foreign materials.

(d). Flavors resulting from exposure of milk to conditions which may cause a physical or chemical change.

Flavors Present When the Milk is Drawn

Materials and feed consumed by the cow:

Any type of treatment with a highly volatile medicine such as iodoform may impart an off-flavor to milk for several days. Highly flavored feeds and weeds will cause an off-flavor in milk. Many of the succulent green feeds have strong flavors which can be transmitted to the milk. Usually the common dry feeds do not contain the highly flavored constituents. It is best to feed the strong-flavored feeds several hours before or immediately after milking.

Internal or physical condition of the individual cow:

Abnormal udders, which vary the chemical composition of the milk, may cause off-flavors. Digestive disorders and constipation of the cow may cause abnormal flavors. The cow in late lactation may have a high chlorine salt and a low sugar content in her milk which may cause an off-flavor.

Flavors Developed After Milk is Drawn

Odors absorbed in the milk:

Milk may absorb any volatile odor from its environment. Keeping milk in uncovered containers and storing it in poorly ventilated places may cause it to be off-flavored.

Bacterial development in milk:

Careless handling and unclean utensils furnish microorganisms which may cause abnormal fermentations; giving rise to various off-flavors.

Contamination of milk with foreign materials:

Any foreign material as rust, oil, gasoline, sterilizers, disinfectants and soaps may cause off-flavors in dairy products. Care should be exercised in handling utensils to prevent contamination of dairy products by any foreign material.

Conditions which may cause physical or chemical changes:

In the development of the pasteurization process one of the problems has been an off-flavor described as cooked or heated. This is usually due to heating milk too fast or holding it too long at pasteurization temperatures. Another objectionable flavor may be produced by freezing milk and holding it at a low temperature for some time. The exposure of milk to direct or indirect rays of the sun produces an off-flavor. It is thought this practice oxidizes the fat and produces a tallowy flavor. Chemical changes which may be catalyzed by heat, light and metallic salts usually produce the off-flavor in which we are particularly interested, namely: oxidized flavor.

One of the most common and most serious off-flavors in dairy products is classed as an oxidized flavor. Oxidized flavor in milk, as a serious problem, is of rather recent development. The flavor is not at all new, but it has not been so prominent until the last decade. Unlike some of the other off-flavors, oxidized flavor is most prevalent in milk from the best plants.

REVIEW OF LITERATURE

In 1920, Hammer and Cordes (14) published an article on tallowy flavors in fluid milk. They found the exposure of milk to sunlight for a short period produced this abnormal flavor. Frazier (10), in 1928, stated a cardboardy flavor developed in milk upon exposure to sunlight.

Hunziker (16), Guthrie (12), and others (15), (31) observed that this flavor defect may be produced by certain metals and metallic salts.

In 1931, Kende (19) mentioned another possible cause of oxidized flavors. He found this flavor defect was more common during the winter when there was a scarcity of fresh green feeds. Kende believed this off-flavor was due to an enzyme which he called "oleinase". According to Kende this enzyme is present in fresh milk from individual cows. He stated that it might be retarded by bacteria or milk containing a high reductase content.

What is an Oxidized Flavor?

Guthrie and Brueckner (13) concluded that oxidized flavor in milk was identical to that known as astringent, papery, cardboardy, metallic, metallic and oily and tallowy. In their opinion the only difference in these flavors was in the intensity of the oxidation. They stated that sunlight and metallic salts acted upon the milk fat to bring about this oxidation.

Thurston, Brown and Dustman (30) of the University of West Virginia did not agree with Guthrie (13) and his co-workers. They believe that lecithin, which is the chief phospholipid of milk, is the constituent effected when oxidized flavor develops. Metallic salts probably catalyze or hasten the oxidation of lecithin; whereas, sunlight produces a flavor which resembles the tallowy flavor of oxidized butter fat. These men prepared a washed butter fat in order to remove any substance adsorbed on the fat globule. Cream was diluted, separated, rediluted and re-separated until no trace of phosphorus could be found which would indicate the samples were practically free of phospholipids.

Fresh skim milk of good flavor and washed butter fat were homogenized together to give as nearly as possible the same sized fat globules as were found in the original milk. The remade milk was contaminated with copper and air was bubbled through it in an attempt to develop an oxidized flavor. The oxidized flavor failed to develop in the remade milk from which the lecithin had been extracted. No trouble was encountered, however, in developing oxidized flavor in the control sample.

Thurston and Brown (29) prepared a milk lecithin from dried buttermilk. Some of this lecithin was added to samples of synthetic milk. The synthetic milk containing lecithin when contaminated with copper gave an oxidized flavor in every case, whereas; the control samples of synthetic milk gave no oxidized flavor.

The Susceptibility of Different Milks to the Development of Oxidized Flavors

Numerous investigators have determined that all milk treated in the same manner does not develop the same degree of oxidized flavor. Under identical conditions some milk will be entirely free of this flavor.

Guthrie and Brueckner (13) used the Cornell Experiment Station herd in determining the susceptibility of different cows' milk to oxidized flavor. As a precaution against contamination by metals or exposure to sunlight, the milk was drawn from the cow directly into sterile amber colored milk bottles. These samples were pasteurized, within two hours after milking, at 143° F. for thirty minutes. They were cooled to 50° F. in thirty minutes after pasteurization, and held at 40° F. for three days.

The samples were then scored for oxidized flavor. From a herd of one hundred fifty-five cows, twenty one percent gave milk that developed oxidized flavors. However, the same cows did not produce milk that oxidized every day. Some cows produced milk which oxidized more often than others. They concluded the cows were very irregular in the production of milk which would develop oxidized flavor. There was no correlation between breed or period of lactation and the development of oxidized flavors. It was thought that feed might have influenced oxidized flavors as the flavor was more prevalent in winter than in summer.

Brown, Thurston and Dustman (2) state that milk given by cows when they are on dry feed has a greater tendency to develop oxidized flavor than milk from the same cows when they are on green pasture. They also found that one quart of either tomato or lemon juice added daily to the dry ration of each cow reduced the tendency of the milk to oxidize. One-half gram of ascorbic acid per cow daily also reduced the development of this flavor.

Anderson (1) found that the addition of carrots to a ration of grain, silage and field-cured alfalfa hay prevented the spontaneous development of oxidized flavor. The oxidized flavor reoccurred seven days after carrots were taken from the ration.

According to Pien and Herschdoerfee (23) oxidized flavors can be controlled by removing from the ration of the cow feeds high in unsaturated fats and substituting feeds which are high in antioxidants.

Henderson and Roadhouse (11) state that milk produced from animals on sub-maintenance rations showed an increased percentage of unsaturated fats, and also that there was an increased susceptibility in this milk fat toward oxidation.

Dahle and Palmer (7) in their experiments, found that feed consumed by the cow influenced the spontaneous oxidized flavor of the individual cow's milk. They report that the production of oxidized flavor is greatly inhibited when the cow's ration includes green feed such as pasture grasses, green alfalfa and clover.

Kende (20) found that milks of different origins varied in their susceptibility toward oxidized flavor development. This investigator believes milk contains unknown organic compounds depending on the quality of the feed given the cow. If these compounds are in milk in large quantities they will protect the milk against oxidized flavor development. If these protective substances are lacking, the milk is extremely sensitive to metallic salts. He did not intimate what the unknown organic compounds might be.

The Effect of Plant Operations on Oxidized Flavors

With our present knowledge it seems that the prevention of oxidized flavors should begin with the nutrition of the cow. However, the effect of various plant practices on the development of this flavor should be studied.

Rice and Miscall (25) observed that less copper went into solution in milk at boiling temperature than at room temperature, and about three times as much copper went into solution at the pasteurization temperature (145° F.) as at the boiling point.

Chilson (3) believes an oxidizing enzyme is present in skim milk which acts upon the lecithin of the milk to produce oxidized flavors. This enzyme, with the help of copper, is most active at pasteurization temperatures. Pasteurization at 170° F. for ten minutes will destroy this enzyme and prevent the oxidized flavor development.

Recent work by Dahle and Palmer (7) lends proof to Chilson's (3) results. They show by their experiments that the pasteurization temperatures of 145° F. to 160° F. enhance the development of off-flavors while heating the milk to 168° F. will prevent its development.

Dahle (7) agrees with Chilson (3) in saying an enzyme which is present in the serum portion of the milk acts upon the lecithin to produce an oxidized flavor.

Tracy, Ramsey and Ruehe (32) found that homogenization retarded the development of tallowy or oxidized flavor. However, the oxidation reduction potential was not changed by homogenization. They concluded that the homogenization did not stop the oxidation, but made it less possible to detect due to the physical changes brought about in the milk. Their experiments show that pasteurized milk which is usually contaminated with metallic salts is more likely to become tallowy if stored immediately at 40° F. than if held at a temperature of 60° F. to 90° F. from one to six hours before cooling to 40° F.

Dahlberg and Carpenter (5) in sterilizing milk equipment, found that chlorine solutions had a tendency to corrode the metal which would allow more metallic salts to be dissolved in the milk. They recommended that chlorine sterilization be followed by a hot water rinse. The object of the hot water rinse is to remove the chlorine solutions thus preventing metal corrosion. It will also remove any deposit of metallic salts which might be on the equipment. The first hot milk through the equipment is more likely to be contaminated with metallic salts, and it is recommended that this milk be discarded.

Guthrie, Roadhouse and Richardson (12) found that copper and copper alloys lost weight when exposed to sweet milk and produced an oxidized flavor in the milk. In thirty percent of the experiments nickel acted in the same manner. No loss in weight was shown by pure aluminum, glass enamel and carefully tin plated metals and no oxidized flavor was produced by them.

Rice and Miscall (25) state that copper corroded with an oxide surface will yield more metallic salts to milk than copper which has a bright smooth surface. They found copper surfaces were easily corroded by chlorine solutions.

Work at the West Virginia Station under Thurston (30) shows that copper or iron must be in solution before it can cause an oxidized flavor in milk. Results show that approximately fifty times more iron (in the form of ferric chloride) than copper (in the form of cupric sulfate) must be dissolved in milk to cause an oxidized flavor.

Methods Suggested to Retard Oxidized Flavors

The definite constituent in milk which is effected when oxidized flavors develop is not known, neither is there a definite preventative known. However, there are certain practices which will retard the development of this flavor.

In 1932 Kende (20) stated that the development of oxidized flavor could be prevented by the growth of microorganisms. He and his co-worker Kertesz (20) isolated an organism and named it reductobacterium frigidum neutrale. This bacterium was very effective in preventing oxidized flavor in oxidized flavor susceptible milk to which copper had been added. According to Kertesz (20) this organism does not effect the taste, color, odor or other normal properties of milk. It grows in milk at a low temperature and can readily be destroyed by pasteurization.

Tracy, Ramsey and Ruehe (32) state that bacteria and yeast cells have an important part in the control of oxidized flavor in dairy products.

They believe oxygen is removed by the bacteria present in the milk. They contend that milk produced in our best dairies is susceptible to this off-flavor development because of the lack of bacterial metabolism.

Keith and Fouts (18) observed that the addition of .15 percent culture of lactic acid organisms would prevent the flavor if the milk was incubated at 90° F. for thirty minutes.

Low temperatures like low bacteria count seem to have a similar effect in producing oxidized flavors.

Davies (9) states that conditions favoring the development of the off-flavor are low bacterial count and low temperature of storage.

Tracy, Ramsey and Ruehe (32) noted that milk which had been contaminated with copper, was more likely to become oxidized if stored at 40° F. than milk stored at 68° F.

Keith and Fouts (18) found that oxidized flavors could be prevented in the Oklahoma A. and M. Creamery by using one and one-half hours to cool the milk from 50° F. to 36° F. They suggested taking milk off the cooler in half pint bottles at 50° F. and in quart bottles at 42° F. In either case one and one-half hours were required for milk to cool to storage temperature. Higher bottling temperature is not advisable, because of injury to cream line.

Dahle (7) states that the addition of 0.1 to 0.2 percent oat flour will inhibit oxidized flavor in susceptible milk. He also says paper milk bottles which contain 25 and 35 percent oat flour in the paraffin lining will prevent oxidized flavor in milk which has been contaminated with 2 p. p. m. copper.

Oxidized Flavors in Butter

Butter, a concentrated form of milk fat, undergoes chemical changes and flavor defects, due to oxidation, are not uncommon. Tallowiness seems to be the outstanding off-flavor which is due to fat oxidation. This flavor resembles that of tallow and is usually accompanied by a bleaching of color.

Hunziker (17) believes that tallowiness is caused by fat oxidation. Oxidation of the butter fat is brought about by air and is greatly intensified in the presence of light and heat. Metallic salts acting as oxidizing agents, are capable of producing tallowiness in butter in a short time.

Ritter (26) states that oxygen and metallic catalysts intensify oxidative defects and cause such flavors as rancid, tallowy, oily, metallic and oxidized. He believes these oxidative defects result largely from the decomposition of fats and lecithin.

Tracy, Ramsey and Ruehe (32) observe that the incubation of sweet cream at 89^{o} to 90^{o} F. for three days will cause sufficient bacterial growth to inhibit metallic or tallowy flavor in butter churned from this cream. Making good butter from surplus sweet cream obtained from milk and ice cream plants, particularly during the winter months, often proves to be a difficult task. Such cream is usually sufficiently contaminated with metallic salts from vats, coolers, sanitary pipe lines and storage cans to become tallowy when stored at a low temperature. Yet this cream if held at a temperature favorable to S. lactis growth from two to three days will produce butter which will have a higher score and be less susceptible to metallic or tallowy flavor than that made from cream in which no bacterial growth has been encouraged. Due to the low temperature of storage, off-flavor development in storage butter is probably due to chemical changes, rather than bacterial action. Much of our research work proves that oxidative changes in dairy products are more prevalent in the winter months when there is a scarcity of fresh green feeds in the cow's ration. This lends further proof that green feeds furnish some form of antioxidizing materials to milk products.

Dahle and Josephson (8) find an aqueous extract of oat flour added to sweet or sour cream, prior to pasteurization and churning improves the keeping quality of the resulting butter. They used the water extract of oat flour figuring one percent by weight of butter fat. This furnished protection from off-flavor development for two months when stored at 40° F. to 45° F. They also found that when butter was wrapped in parchment which had been treated with oat flour, and stored at 45° F. the development of off-flavor was delayed from three to five weeks.

Oxidized Flavors in Ice Cream

During the winter months oxidized flavor is a serious problem to the dairy industry. It is especially serious to the ice cream manufacturer. The slow turnover at this time of the year allows oxidative changes to take place in cabinets and hardening rooms. Copper contamination is probably one of the main causes of this flavor defect.

Dahle and Folkers (6) find that as little as 1.3 p. p. m. of copper will cause this flavor to develop in strawberry ice cream. The most important source of copper contamination is from condensed milk which has been processed in a vacuum pan containing metallic salts.

Sommer (28) records that copper and iron in solution produces a chemical change which results in a tallowy or cardboardy flavor. Vacuum pans in most plants are used less frequently during the winter months which allows copper oxide to form on the surface. If this oxide is not removed more copper will be dissolved in the product processed in the pan.

Ramsey and Tracy (24) note that the stale metallic flavor in strawberry ice cream is due to oxidation of butter fat which is usually brought about by metallic salts. They believe strawberries, oranges, lemons, and pineapple accelerate the stale metallic flavor. They found that aging fruit in the mix or increasing the amount of fruit often prevented the flavor.

Ross, Bird and Iverson (27) believe that strawberries are not responsible for the tallowy flavor occurring in strawberry ice cream. Control samples containing no strawberries developed the flavor before the samples which contained strawberries. They contend the flavor defect has equally as good a chance to appear in any type of ice cream. They state that metallic salts from the condensing pan hasten the induction of fat oxidation and that little further oxidation is necessary in the ice cream for this flavor to appear.

Dahle and Josephson (8) found that 0.5 percent of oat flour prevented the development of oxidized flavors for several weeks in ice cream which had been contaminated with 2 p. p. m. copper. They also reported that the addition of oat flour to fresh cream which is to be placed in storage will furnish protection to ice cream in which this cream is used as a source of fat.

Mueller and Mack (21) found equally as good results in the use of oat flour as an antioxidant in ice cream. They recommend, however, a reduction of the stabilizer, when oat flour is used, to prevent excessive viscosity and slow whipping of the mix.

EXPERIMENTAL METHODS AND DISCUSSION OF RESULTS

As stated previously this experiment was undertaken to devise methods of preventing the development of oxidized flavors in dairy products. This particular abnormal flavor causes much worry and loss to the processor and manufacturer of dairy products. Milk, butter and ice cream were studied under various conditions with the object of working out methods of preventing the development of oxidized flavors - these methods to be such that they could be adapted to the average commercial plant.

The experimental work was conducted using milk produced by the college herd. No special care was exercised in producing or processing to prevent exposure of the milk to indirect rays of the sun or to prevent contamination from metals. Cream separated from the milk produced by the college herd was used in the studies on butter. In the ice cream studies milk and cream from the college herd were used with spray process skim milk powder as the source of additional milk solids.

The effect of oat flour as an antioxidant was studied in milk, butter and ice cream. Various bases were used to reduce the titratable acidity in the studies on milk and ice cream. The effect of cream ripening and the addition of a S. lactis starter to butter at the time of salting and working were also observed.

The first problem was to prepare solutions with known strength of metallic salts for use in catalyzing oxidized flavors in the various dairy products. Since copper salts have the ability to enhance the development of oxidized flavors it was decided to prepare solutions of copper sulfate, copper chloride and copper lactate. In making up the standard salt solutions of copper sulfate, copper chloride, and copper lactate to be used in the different products of this experiment it was desirable to have them of such concentration that a definite volume of solution could be measured conveniently and quickly and added to a convenient volume or weight of milk or ice cream mix.

For example it was decided to add 2 p. p. m. of copper to milk and since ½ pint was a convenient volume of milk and 1 c. c. a convenient volume of salt solution, the salt solutions were carefully standardized so that 1 c. c. would contain enough copper to furnish 2 p. p. m. in ½ pint of milk. The following calculations will serve to illustrate how the solution of copper sulfate to be used in milk was made.

Weight of ½ pint of milk = .5375 lb. or 243.8 grams.

Then 243.8 x .000002 = .0004876 gram of copper needed for each ½ pint of milk.

The copper sulfate used was $CuSO_4 \cdot 5H_2O$.

One gram molecular weight of this salt is 249.71 grams and this contains 63.57 grams of copper. 1000 c. c. of the desired solution would require .4876 gram of copper (.0004876 x 1000).

Then .4876 : 63.57 :: X : 249.71

X = 1.9153 grams of $CuSO_4 \cdot 5H_2O$ required to make 1000 c. c. of the salt solution.

Similarly when using copper chloride and copper lactate calculations were made and solutions prepared.

The copper chloride used was $CuCl_2$. One gram molecular weight of salt is 134.48 grams and this contains 63.57 grams of copper. Then 1.0338 grams of $CuCl_2$ dissolved in water and made up to 1000 c. c. will give the desired strength solution.

The copper lactate used was $Cu(C_3H_5O_3)_2 \cdot 2H_2O$. One gram molecular weight of this salt is 277.68 grams and this contains 63.57 grams of copper. Then 2.1299 grams of $Cu(C_3H_5O_3)_2 \cdot 2H_2O$ dissolved in water and made up to 1000 c. c. will give the desired strength solution.

In making up standard solutions for ice cream mix it was decided to add 2 p. p. m. of copper to the mix. And since 1 lb. of mix was a convenient weight of mix and 1 c. c. a convenient volume of salt solution, the salt solutions were carefully standardized so that 1 c. c. would contain enough copper to furnish 2 p. p. m. in 1 lb. of mix. The following calculations will serve to illustrate how the solution of copper sulfate to be used in mix was made.

Weight of 1 lb. mix = 453.59 grams.

Then 453.59 x .000002 = .00090718 grams of copper needed for each lb. of mix.

The copper sulfate used was $CuSO_4.5H_2O$.

One gram molecular weight of this salt is 249.71 grams and this contains 63.57 grams of copper.

1000 c. c. of the desired solution would require .90718 gram of copper (.00090718 x 1000).

Then .90718 : 63.57 :: X = 249.71

X = 3.5635 grams of $CuSO_4.5H_2O$ required to make 1000 c. c. of the salt solution.

Similarly when using copper chloride and copper lactate calculations were made and solutions prepared.

The copper chloride used was $CuCl_2$.

One gram molecular weight of this salt is 134.48 grams and contains 63.57 grams of copper. Then 1.9191 grams of $CuCl_2$ dissolved in water and made up to 1000 c. c. will give the desired strength solution.

The copper lactate used was $Cu(C_3H_5O_3)_2.2H_2O$.

One gram molecular weight of this salt is 277.68 grams and this contains 63.57 grams of copper. Then 3.9626 grams of $Cu(C_3H_5O_3)_2.2H_2O$ dissolved in water and made up to 1000 c. c. will give the desired strength solution.

Of the three copper salt solutions prepared the copper sulfate solution was used most frequently in catalyzing the oxidized flavor in the various dairy products. Copper lactate was eliminated because of cost ($12.50 per lb.). Copper chloride did not prove to be as effective as copper sulfate in catalyzing the oxidized flavor.

In all dairy products the organoleptic method was used in detecting the presence of the oxidized flavors.

Milk I Paper Milk Bottles

To hasten the development of oxidized flavors milk was exposed to 15 minutes direct sunlight or 2 p. p. m. copper ($CuSO_4 \cdot 5H_2O$) was added. The sunlight and copper act as catalysts.

Milk produced by the college herd was standardized to 4.0 percent butter fat with separated skim milk from the same source. The milk was then warmed to 90° F. and filtered through a cotton tubular filter before entering a stainless steel spray pasteurizer. After pasteurization at 143° F. for thirty minutes the milk was pumped over a tinned copper tubular cooler which was covered with a close fitting cover. The milk was then bottled. The samples used in this experiment were taken after the milk had been processed and was ready for sale. In this experiment some of the paper milk bottles contained 25 and 35 percent oat flour (Avenex Number 7) replacing this percentage of paraffin in the lining of the bottle. One bottle of milk from each group was exposed to 15 minutes direct sunlight. One bottle from each group was contaminated with 2 p. p. m. copper, while one bottle from each group had the combination of exposure to 15 minutes direct sunlight and contamination with 2 p. p. m copper ($CuSO_4 \cdot 5H_2O$).

As shown in table 1 paper milk bottles which contained 25 and 35 percent oat flour (Avenex Number 7) in the paraffin lining of the bottles gave favorable results in delaying the development of oxidized flavors in the untreated milk. The development of the flavor was not prevented however, when the milk was contaminated with as much as 2 p. p. m. copper or exposed to 15 minutes direct sunlight or both. An objectionable oat flavor developed in the milk in most of the bottles containing oat flour which would have rendered it unsalable.

Table 1

The effect of oat flour-treated paraffin lined paper milk bottles on oxidized flavor development in pasteurized milk

Sample number	Treatment of sample	Number of *observations	Percent of observations indicating oxidized flavor: 1st day	2nd day	3rd day	4th day	5th day
1	Control glass bottle	60	0	33	72	100	100
2	Glass bottle + 2 p. p. m. copper	60	83	100	100	100	100
3	Glass bottle + 15 minutes sunlight	60	72	97	100	100	100
4	Glass bottle + 2 p.p.m. copper + 15 minutes sunlight	60	100	100	100	100	100
5	Control paper bottle no oat flour	60	0	66	90	100	100
6	Paper bottle no oat flour + 2 p. p. m. copper	60	66	100	100	100	100
7	Paper bottle no oat flour + 15 minutes sunlight	60	50	86	100	100	100
8	Paper bottle no oat flour + 2 p. p. m. copper + 15 minutes sunlight	60	100	100	100	100	100
9	Control paper bottle 25 percent oat flour	60	0	0	0	0	33
10	Paper bottle 25 percent oat flour + 2 p. p. m. copper	60	33	75	100	100	100
11	Paper bottle 25 percent oat flour + 15 minutes sunlight	60	20	60	89	100	100
12	Paper bottle 25 percent oat flour + 2 p. p. m. copper + 15 minutes sunlight	60	100	100	100	100	100
13	Control paper bottle 35 percent oat flour	60	0	0	0	0	22
14	Paper bottle 35 percent oat flour + 2 p. p. m. copper	60	15	37	90	100	100
15	Paper bottle 35 percent oat flour + 15 minutes sunlight	60	10	25	80	100	100
16	Paper bottle 35 percent oat flour + 2 p. p. m. copper + 15 minutes sunlight	60	100	100	100	100	100

*An observation means one judge's score on one sample.

Milk II Hexane Extract of Oat Flour

Hexane extract of oat flour was added to milk produced by the college herd at the rate of $\frac{1}{2}$ c. c. of hexane extract to each quart of milk. The hexane extract was emulsified with skim milk in a hand emulsifier. One hundred and thirty three (133) cubic centimeters of skim milk were used to 7 c. c. of hexane extract. This mixture was heated to 143° F. and run through the emulsifier three times at the maximum possible pressure with this emulsifier. Ten (10) cubic centimeters of this skim milk-hexane extract mixture were used per quart of milk which gave $\frac{1}{2}$ c. c. of hexane extract per quart of milk. The milk was cooled to 40° F. over a surface cooler, then bottled in the various type bottles used in the experiment. Duplicate samples were carried in glass bottles, paper bottles containing no oat flour and in paper bottles containing 25 and 35 percent oat flour in the paraffin lining. Control samples which contained ten (10) c. c. of plain emulsified skim milk were carried in each type bottle and subjected to same treatment of contamination with 2 p. p. m. copper as were the samples containing the hexane extract.

Hexane extract of oat flour when added at the rate of $\frac{1}{2}$ c. c. per quart of milk did not prevent the development of oxidized flavor in either the glass or plain paraffined paper bottle when it was contaminated with 2 p. p. m. copper. When the hexane extract was added to milk in the oat flour treated paper bottles, a slight protective action was observed but in all cases where the hexane extract was added a very objectionable oat and oily flavor developed in the milk.

Table 2

Effect of hexane extract of oat flour in preventing oxidized flavor in pasteurized milk

Sample number	Treatment of sample	Number of observations	Percentage of observations indicating oxidized flavor				
			1st day	2nd day	3rd day	4th day	5th day
1	Control glass bottle	10	100	100	100	100	100
2	Glass bottle + hexane extract	10	100	100	100	100	100
3	Glass bottle + 2 p. p. m. copper	10	100	100	100	100	100
4	Glass bottle + 2 p. p. m. copper + hexane extract	10	100	100	100	100	100
5	Control paper bottle	10	100	100	100	100	100
6	Paper bottle + hexane extract	10	50	100	100	100	100
7	Paper bottle + 2 p. p. m. copper	10	100	100	100	100	100
8	Paper bottle + 2 p. p. m. copper + hexane extract	10	100	100	100	100	100
9	Control paper bottle + 25 percent oat flour	10	0	70	100	100	100
10	Paper bottle + 25 percent oat flour + hexane extract	10	0	0	70	100	100
11	Paper bottle + 25 percent oat flour + 2 p. p. m. copper	10	100	100	100	100	100
12	Paper bottle + 25 percent oat flour + 2 p. p. m. copper + hexane extract	10	40	100	100	100	100
13	Control paper bottle + 35 percent oat flour	10	0	0	60	100	100
14	Paper bottle + 35 percent oat flour + hexane extract	10	0	0	50	100	100
15	Paper bottle + 35 percent oat flour + 2 p. p. m. copper	10	100	100	100	100	100
16	Paper bottle + 35 percent oat flour + 2 p. p. m. copper + hexane extract	10	60	100	100	100	100

Milk III Adding Oat Flour Directly to Milk

Oat flour (Avenex Number 7) was added directly to milk at the rate of 0.2 to 0.5 percent. The milk was then standardized to 4.0 percent butter fat and pasteurized in five gallon cans to 143° F. for thirty minutes. The milk was cooled over a surface cooler and bottled directly in glass quart bottles for the experiment. Control samples which contained no oat flour were carried with the samples containing oat flour and were subjected to the same treatment. One bottle of milk containing oat flour was kept as a control. One bottle was exposed to 15 minutes direct sunlight. One bottle was contaminated with 2 p. p. m. copper ($CuSO_4 \cdot 5H_2O$), while one bottle had the combination of exposure to 15 minutes direct sunlight and contamination with 2 p. p. m. copper.

As shown in table 3 the addition of 0.2 to 0.5 percent oat flour directly to milk before pasteurization gave protection against the development of oxidized flavors in regular pasteurized milk. However little protective action was observed when the milk was contaminated with 2 p. p. m. copper or exposed to 15 minutes direct sunlight or both.

Oat flour (Avenex Number 7) was not very soluble and a brownish residue was left in the bottom of the bottles. No effective means of removing or preventing the sediment of oat flour was found.

When oat flour (Avenex Number 7) was added directly to the milk a ten percent deeper cream layer formed on the milk.

Table 3

Effect of oat flour in preventing oxidized flavor when added directly to milk

Sample number	Treatment of sample	Number of observations	Percentage of observations indicating oxidized flavor				
			1st day	2nd day	3rd day	4th day	5th day
1	Control glass bottle no oat flour	10	0	0	40	90	100
2	Control glass bottle + 0.2 to 0.5 percent oat flour	10	0	0	0	0	0
3	Glass bottle + 0.2 to 0.5 percent oat flour + 15 minutes sunlight	10	0	50	100	100	100
4	Glass bottle + 0.2 to 0.5 percent oat flour + 2 p. p. m. copper	10	0	100	100	100	100
5	Glass bottle + 0.2 to 0.5 percent oat flour + 2 2 p. p. m. copper + 15 minutes sunlight	10	100	100	100	100	100

Milk IV A Water or a Milk Extract of Oat Flour

A water or a milk extract of oat flour was used in this experiment because of failure to find any satisfactory method of removing the undissolved portion of oat flour after it had been added directly to the milk. These extracts were made by allowing a mixture of oat flour (Avenex Number 7) in water or milk to stand for twelve hours in the milk cooling room (50° F.). Then the top soluble portion was siphoned off and added directly to milk before pasteurization. Extracts of oat flour were prepared by using 0.2 to 0.5 percent of oat flour by weight of milk. The oat flour was mixed at the rate of one part oat flour to sixteen parts milk or water. After processing and bottling the samples were divided into four groups. One group was used as a control, one group was exposed to 15 minutes direct sunlight, one group was contaminated with 2 p. p. m. copper, while the other group was contaminated with 2 p. p. m. copper and exposed to 15 minutes direct sunlight. A control which contained no extract of oat flour was also carried with this experiment.

As shown in table 4 water or milk extracts of oat flour (Avenex Number 7) gave favorable results in preventing the development of oxidized flavors in the untreated milk. However, little protective action was observed when the milk was contaminated with 2 p. p. m. copper or exposed to 15 minutes direct sunlight or both.

The use of water or milk extracts seems to be the only way of utilizing the antioxidative property of oat flour in milk since this process eliminates the problem of sediment and is equally as effective in protective action as the addition of oat flour directly to the milk.

Table 4

Effect of water or milk extracts of oat flour in retarding oxidized flavor in milk

Sample number	Treatment of sample	Number of observations	Percentage of observations indicating oxidized flavor: 1st day	2nd day	3rd day	4th day	5th day
1	Control glass bottle no extract of oat flour	10	0	0	20	100	100
2	Control glass bottle extract of oat flour	10	0	0	0	0	0
3	Glass bottle extract of oat flour + 2 p. p. m. copper	10	0	100	100	100	100
4	Glass bottle extract of oat flour + 15 minutes sunlight	10	0	50	100	100	100
5	Glass bottle extract of oat flour + 2 p. p. m. copper + 15 minutes sunlight	10	100	100	100	100	100

Milk V Reducing the Acidity with Bases

The titratable acidity of milk was reduced from approximately .19 to .15 percent with sodium carbonate, sodium bi-carbonate and a commercial preparation known as "milk mineral salts". In calculating the amount of each neutralizer to use the titratable acidity of the milk was determined by titrating an 18 gram sample with N/10 NaOH using phenolphthalein as an indicator. The samples were neutralized, pasteurized, cooled, bottled and treated for the experiment. A control sample which had not been neutralized was used in each experiment. One sample was neutralized only, one sample was contaminated with 2 p. p. m. copper, one sample was exposed to 15 minutes direct sunlight, while the fourth sample containing neutralizer was contaminated with 2 p. p. m. copper and exposed to direct sunlight for 15 minutes. Sodium citrate was used under identical conditions at the rate of 0.1 to 0.3 percent by weight. All samples were scored for flavor daily after the samples were treated.

The results show that sodium carbonate, sodium bi-carbonate, "milk mineral salts" and sodium citrate were effective in delaying the development of oxidized flavor in regular pasteurized milk. However, these neutralizers did not prevent the development of the abnormal flavor when the milk was contaminated with 2 p. p. m. copper or exposed to 15 minutes direct sunlight or both.

Sodium citrate gave an undesirable salty flavor to milk when used in excess of 0.2 percent.

Since carbonates and citrates are natural constituents of milk it seems the addition of these substances is perhaps justified, whereas oat flour should be classed as a foreign material and is not practicable.

Greater difficulty was found in catalyzing the oxidized flavor in the spring and summer when there was an abundance of green feeds. Very

Table 5

Effect of reducing the titratable acidity on the oxidized flavor in milk

Sample number	Treatment of sample	Number of observations	Percentage of observations indicating oxidized flavor 1st day	2nd day	3rd day	4th day	5th day
	SODIUM CARBONATE						
1	Control glass bottle not neutralized	10	0	0	70	100	100
2	Control glass bottle neutralized	10	0	0	0	0	0
3	Glass bottle neutralized + 2 p. p. m. copper	10	70	100	100	100	100
4	Glass bottle neutralized + 15 minutes direct sunlight	10	0	100	100	100	100
5	Glass bottle neutralized + 2 p. p. m. copper + 15 minutes sunlight	10	100	100	100	100	100
	SODIUM BI-CARBONATE						
1	Control glass bottle not neutralized	12	0	0	70	100	100
2	Control glass bottle neutralized	12	0	0	0	0	0
3	Glass bottle neutralized + 2 p. p. m. copper	12	70	100	100	100	100
4	Glass bottle neutralized + 15 minutes sunlight	12	0	100	100	100	100
5	Glass bottle neutralized + 2 p. p. m. copper + 15 minutes sunlight	12	100	100	100	100	100
	MILK MINERAL SALTS						
1	Control glass bottle not neutralized	10	0	0	70	100	100
2	Control glass bottle neutralized	10	0	0	0	0	0
3	Glass bottle neutralized + 2 p. p. m. copper	10	85	100	100	100	100
4	Glass bottle neutralized + 15 minutes direct sunlight	10	60	100	100	100	100
5	Glass bottle neutralized + 2 p. p. m. copper + 15 minutes direct sunlight	10	100	100	100	100	100
	SODIUM CITRATE						
1	Control glass bottle no sodium citrate	10	0	0	70	100	100
2	Control glass bottle sodium citrate	10	0	0	0	90	100
3	Glass bottle sodium citrate + 2 p. p. m. copper	10	100	100	100	100	100
4	Glass bottle sodium citrate + 15 minutes direct sunlight	10	0	100	100	100	100
5	Glass bottle sodium citrate + 2 p. p. m. copper + 15 minutes sunlight	10	100	100	100	100	100

little milk spontaneously developed this flavor during the spring and summer; whereas, the milk from the college herd was very susceptible to the development of this flavor during the winter when there was a scarcity of fresh green feeds.

The flavor which develops in milk that has been contaminated with metallic salts is probably different from that produced in milk which has been exposed to sunlight. The exposure of milk to sunlight develops a flavor resembling that of tallow, while the flavor developed when milk is contaminated with copper salts resembles the cappy or cardboardy flavor.

Butter I Water Extract of Oat Flour

A water extract of oat flour at the rate of one pound oat flour to 100 pounds of butter fat was prepared by mixing one pound of oat flour with two gallons of water and allowing this mixture to set in the cold milk room (50° F.) for twelve hours. The water soluble fraction was siphoned off and added to cream after neutralization and before pasteurization. The cream was ripened in each case for twenty four hours before churning. A control churning of identical cream, without the extract of oat flour, was carried in each experiment.

As shown in table 6 a water extract of oat flour when added to cream before pasteurization, furnished a protective action against the development of rancidity in butter for about fourteen days. After this time no beneficial results were observed.

Butter II Oat Flour Treated Parchment

Oat flour treated parchment was used in wrapping butter to determine its effectiveness in preventing abnormal flavors. Butter made from cream which had not been treated with an extract of oat flour (Avenex Number 7) was wrapped in treated and untreated parchment in pound and $\frac{1}{4}$ pound sizes and stored at a temperature of approximately 50° F.

Favorable results were found in wrapping butter in oat flour treated parchment. Regular butter was showing rancidity in approximately five days. When the butter was wrapped in oat flour treated parchment protective action was furnished for an additional period of five days. After this time no difference in butter wrapped in treated or untreated parchment was observed.

Table 6

Effect of water extracts of oat flour on the development of abnormal flavors in butter

Sample number	Treatment of sample	Number of observations	Percentage of observations showing rancid flavor													
			1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day
1	No extract of oat flour	14	0	0	0	0	0	20	70	100	100	100	100	100	100	100
2	Extract of oat flour	14	0	0	0	0	0	0	0	0	0	0	0	0	0	50

Table 7

Effect of oat flour treated parchment on rancid flavor development in butter

Sample number	Treatment of sample	Number of observations	Percentage of observations showing rancid flavor													
			1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day
1	¼ pound size plain parchment	14	0	0	0	0	0	50	100	100	100	100	100	100	100	100
2	¼ pound size treated parchment	14	0	0	0	0	0	0	0	0	0	33	80	100	100	100
3	Solid pound size plain parchment	14	0	0	0	0	0	50	100	100	100	100	100	100	100	100
4	Solid pound size treated parchment	14	0	0	0	0	0	0	0	0	0	40	90	100	100	100

Butter III — Ripening Cream and Adding Starters Directly to Butter when Salting and Working

After pasteurizing sweet cream for butter making a culture of S. lactis organisms was added to increase the acidity from .16 to .30 percent in the cream which was used in churning Number one. One quart culture of S. lactis organisms was added directly to 100 pounds of butter fat churned from sweet cream at the time of salting and working in churning Number two. Churning Number three was made from identical cream in which no bacterial growth had been encouraged. The butter from these three churnings was stored under identical conditions and scored daily for three weeks.

In no case was cream contaminated with copper or exposed to sunlight to catalyze the abnormal flavor development. All cream was pasteurized, cooled and ripened in a 50 gallon coil vat. The cream was churned in a combined churn and butter worker.

The ripening of sweet cream with S. lactis organisms to an acidity of .30 percent produced butter with a better keeping quality than identical sweet cream in which no acidity had been developed.

The development of acidity before churning or the addition of one quart of S. lactis culture per 100 pounds of fat directly to the butter when salting and working gave favorable results in delaying the development of rancid flavors.

In the experiments on butter no flavor was produced which was identical to the oxidized flavor in milk and ice cream. Perhaps the rancid flavor in butter is comparable to the oxidized flavor in milk and ice cream. Milk from the college herd is susceptible to the development of oxidized flavors, and butter manufactured from cream produced from this milk is very susceptible to the development of rancidity.

Table 8

Effect of adding starter to cream or butter on the development of rancid flavor

Sample number	Treatment of sample	Number of observations	Percentage of observations showing rancid flavors													
			1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day
1	Acidity not increased	42	0	0	0	0	0	30	80	100	100	100	100	100	100	100
2	Acidity increased	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Culture added to butter at time of salting and working	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ice Cream I

0.3 Percent Oat Flour Replacing 0.3 Percent Serum Solids

Oat flour (Avenex Number 7) was used to replace 0.3 percent serum solids in the ice cream mix. The mix compositions were as follows: Mixes one and two - 12 percent fat, 12 percent serum solids, 14.5 percent sugar, 0.25 percent gelatin. Mixes three and four - 12 percent fat, 11.7 percent serum solids, 0.3 percent oat flour, 14.5 percent sugar, 0.25 percent gelatin. Mixes were made in groups of four 50 pound mixes to each experiment. The mixes in each experiment were made from identical dairy products and had the same percentage composition, except that in mixes three and four in each case 0.3 percent oat flour replaced 0.3 percent serum solids. The mixes were pasteurized at 160° F. for twenty minutes in ten gallon cans, homogenized at 2500 plus 1000 pounds pressure, cooled over a surface cooler and aged for twenty four hours before freezing. Mixes two and four in each experiment were contaminated with 2 p. p. m. copper immediately after cooling. Mixes one and two in each experiment were used as controls.

Favorable results as shown in table 9 were obtained in delaying the development of oxidized flavors in ice cream when 0.3 percent oat flour (Avenex Number 7) replaced 0.3 percent serum solids in the mix. Regular ice cream was showing oxidized flavor in approximately eleven weeks. When 0.3 percent oat flour was used to replace 0.3 percent serum solids, no off-flavor was evident at the end of fifteen weeks. When mixes were contaminated with 2 p. p. m. copper, the regular ice cream developed an oxidized flavor in five weeks; ice cream containing 0.3 percent oat flour showed a slight oxidized flavor in nine weeks. Some of the samples in which all of the oat flour failed to dissolve were criticized as having a slight cereally or starchy flavor.

Table 9

Effect of substituting 0.3 percent oat flour for 0.3 percent serum solids on oxidized flavor in ice cream

Sample number	Treatment of sample	Number of observations	Percentage of observations showing oxidized flavor by weeks														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Control no oat flour	75	0	0	0	0	0	0	0	0	0	0	30	90	100	100	100
2	No oat flour + 2 p. p. m. copper	75	0	0	0	0	0	95	100	100	100	100	100	100	100	100	100
3	Control 0.3 percent oat flour	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0.3 percent oat flour + 2 p. p. m. copper	75	0	0	0	0	0	0	0	0	75	100	100	100	100	100	100

Ice Cream II Treated Parchment and Cups

Parchment and paper cups that had been treated with oat flour (Avenex Number 7) were used to determine their effectiveness in retarding the development of oxidized flavors, when the ice cream was and was not contaminated with copper. Control mixes were made containing no oat flour. These mixes were divided into three groups. One mix was kept as a control, one mix was contaminated with 1 p. p. m. copper and the third mix was contaminated with 2 p. p. m. copper. The mixes were frozen. Samples of the ice cream were taken from the freezer and placed in the treated cups. Other samples were placed in brick pans to harden and were then cut into quart bricks and wrapped in treated parchment. The samples were scored each week for fifteen weeks.

No protective action was observed in plain ice cream, which was contaminated with 2 p. p. m. copper and wrapped in treated parchment or placed in treated cups.

The Avenex treated parchment and cups were found to have a slight protective action in delaying the development of oxidized flavors in ice cream which was contaminated with 1 p. p. m. copper. Ice cream contaminated with 1 p. p. m. copper was showing an oxidized flavor in approximately five weeks. When this ice cream was wrapped in treated parchment or placed in treated cups protective action was furnished for an additional week.

In the control samples which contained no added copper there seemed to be little protective action furnished by the avenized parchment and containers.

Table 10

Effect of treated parchment and cups on oxidized flavor in ice cream

Sample number	Treatment of sample	Number of observations	Percentage of observations showing oxidized flavor by weeks														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Control plain parchment and cups	30	0	0	0	0	0	0	0	0	0	30	90	100	100	100	100
2	Treated parchment and cups	30	0	0	0	0	0	0	0	0	0	20	85	100	100	100	100
3	Control plain parchment and cups + 1 p. p. m. copper	30	0	0	0	0	30	85	100	100	100	100	100	100	100	100	100
4	Treated parchment and cups + 1 p. p. m. copper	30	0	0	0	0	0	40	90	100	100	100	100	100	100	100	100
5	Control plain parchment and cups + 2 p. p. m. copper	30	0	0	30	95	100	100	100	100	100	100	100	100	100	100	100
6	Treated parchment and cups + 2 p. p. m. copper	30	0	0	30	95	100	100	100	100	100	100	100	100	100	100	100

Ice Cream III — Reducing the Acidity of Mix with Sodium Bi-carbonate

Sodium bi-carbonate was used to reduce the titratable acidity of mixes from approximately .34 percent down to .20 percent. Four 50 pound mixes were made from identical dairy products and two of these mixes were neutralized with $NaHCO_3$ to .20 percent before pasteurizing and processing. One of the mixes which contained no neutralizer and one of the mixes which had been neutralized were contaminated with 2 p. p. m. copper soon after cooling. The other two mixes were used as controls.

All the ice cream mixes were pasteurized in milk cans by placing the cans of mix in hot water and using a stirring rod for the purpose of agitating the mixes while heating. The mixes were homogenized at 2500 plus 1000 pound pressure, cooled over a surface cooler, aged twenty four hours and frozen in a direct expansion forty quart horizontal freezer. This ice cream was scored once each week for twelve weeks.

Sodium bi-carbonate, when used to reduce the acidity in ice cream mixes from approximately .34 percent to .20 percent, was found to furnish protective action in delaying the development of oxidized flavors in ice cream when it was and was not contaminated with 2 p. p. m. copper. The control samples containing 2 p. p. m. added copper which were not neutralized developed the oxidized flavor in six weeks. The neutralized sample containing 2 p. p. m. added copper did not develop this off-flavor in twelve weeks. In the ice creams which were neutralized with sodium bi-carbonate, one of which was contaminated with copper, a protective action against flavor deterioration was found even though neither of these samples developed an oxidized flavor in the twelve-week period.

Table 11

Effect of reducing the titratable acidity of mix on oxidized flavor development in ice cream

Sample number	Treatment of sample	Number of observations	Percentage of observations showing oxidized flavor by weeks											
			1	2	3	4	5	6	7	8	9	10	11	12
1	Control not neutralized	48	0	0	0	0	0	0	0	0	0	10	75	100
2	Not neutralized + 2 p. p. m. copper	48	0	0	0	0	0	80	100	100	100	100	100	100
3	Control neutralized	48	0	0	0	0	0	0	0	0	0	0	0	0
4	Neutralized + 2 p. p. m. copper	48	0	0	0	0	0	0	0	0	0	0	0	0

CONCLUSIONS

1. Paper milk bottles containing 25 and 35 percent oat flour in the paraffin lining gave a protective action against the development of oxidized flavors in milk. However, an oat flavor was imparted to most of the samples.

2. Little protective action was observed from oat flour when the milk was contaminated with 2 p. p. m. copper or exposed to 15 minutes sunlight or both.

3. Hexane extract of oat flour furnished little protective action in delaying oxidized flavors and caused a very objectionable oat and oily flavor in the milk.

4. The addition of oat flour directly to milk prior to pasteurization gave protective action against the development of oxidized flavors. A brownish residue of oat flour was left in the bottom of the bottle which was very objectionable. No satisfactory method of removing this undissolved oat flour was found.

5. Water or milk extracts of oat flour gave favorable results in preventing oxidized flavor development in milk. However, little protective action was observed when the milk was contaminated with 2 p. p. m. copper or exposed to sunlight for 15 minutes or both.

6. Reducing the titratable acidity with sodium carbonate, sodium bi-carbonate and "milk mineral salts" retarded oxidized flavor development in regular pasteurized milk. Sodium citrate also proved effective in retarding the development of this flavor; however, a salty flavor was produced when sodium citrate was used in excess of 0.2 percent.

7. A slight protective action against the development of rancidity was observed in butter made from cream to which a water extract of oat flour had been added.

8. A slight protective action against the development of rancidity was found when butter was wrapped in treated parchment.

9. Developing the acidity of sweet cream before churning or adding starter to butter at time of salting and working helps prevent the development of rancidity in butter.

10. The use of 0.3 percent oat flour to replace 0.3 percent serum solids in the ice cream mix may prove valuable in preventing off-flavors in ice cream.

11. Treated parchment and cups were not effective in preventing oxidized flavor development in ice cream to which copper had been added.

12. Reducing the titratable acidity of ice cream mixes helped to retard abnormal flavor development.

13. Copper salts acting as catalysts hasten the development of oxidized flavors in dairy products.

14. In this experiment it was believed that the flavor developed in milk that had been contaminated with copper salts was different from that developed in milk which had been exposed to sunlight.

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